Of Water Troughs and the Sun

Developing Inquiry through Analogy

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All perception of truth is the perception of analogy; we reason from our hands to our head.

—*Henry David Thoreau*

Maria, Angelique, and Tasha kneel and lean forward, looking closely at the clover in the school yard. One, then another, feels the plant. Tasha nods and opens a plastic baggie, and the three first-graders add clover leaves and flowers to their collection of dandelions and cedar. The three girls soon join their classmates—and the buzz of conversation—as they line up to go back to their classroom to continue their science lesson.

Observing patterns in the natural world

The lesson that this group of first-graders at Eastside Elementary in Chattanooga, Tennessee, excitedly anticipates is one in a series designed to address the content standards related to science as inquiry (NRC 1996). As such, the lessons reflect "what students need to know, understand, and be able to do to be scientifically literate" (NRC 1996, 2). They encourage children to interact with their environment, ask questions, and find ways to answer the questions they have raised. The science content lessons are introduced and taught through inquiry experiences.

What is novel about the approach to teaching scientific inquiry at Eastside is that the children are on a perpetual search for patterns. The lessons—drawn from a study carried out by the first author of this discussion (Cowan 2001) and from adaptations of lessons from *The Private Eye* (Ruef 1992)—lead children to recognize, describe, and extend simple repetitive patterns. Children collect data through their senses, paying particular attention to what they can see. As a part of each lesson, children look closely at objects or structures, search for repeating patterns, and guess or hypothesize about the nature of the objects, based on their prior knowledge and the observable patterns.

Observing and analogies

Visual intelligence is a key element in the thought processes of the most capable and creative among us (Bronowski 1973; 1978), and this intelligence is closely related to analogical thinking, a learner's ability to make connections between prior knowledge and newly presented information (Ganguly 1995; May, Hammer, & Roy 2006). Thus, each inquiry lesson begins with a drawing

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or other visual literacy connection. Drawing, by its very nature, encourages visualization, which in turn positions the learner to think metaphorically (Cowan 2001; Cowan & Albers 2006). The premise that in nature, "form follows function" also underpins each lesson.

Because many first-graders have experienced the loss of their front teeth (and are interested in this topic), in one of the first science lessons, the teacher discusses the function of the new incisors that children soon will have. After explaining that the incisors, or front teeth, are shaped like cutting implements, the teacher asks the children, "What is the function of incisors?" Children respond that tearing or cutting food is their function. Similarly, the teacher has the children feel their fingernails, then asks, "What do you think the function of the nail is?" Children quickly respond with stories about someone scratching them and decide that the function of nails is to protect us.

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After this discussion, the teacher gives children objects from nature, such as fur, hair, dandelion helicopters, and maple seeds. The teacher has the children look closely at each object, state what (if anything) it reminds them of, and then guess or hypothesize what the purpose or function of the object might be. Since drawing requires close observation, the children draw the objects in each lesson.

This process activates the children's natural curiosity, which becomes a driving force for the inquiry lessons. With observation and inquiry, children build background experiences necessary to shape complex scientific reasoning. They become skilled in using descriptive language and are able to state their positions in greater detail. Children also learn to gather data, organize their ideas, and evaluate natural phenomena in their world. The skills needed for observation support all disciplines, particularly reading (Anderson, Martin, & Faszewski 2006; Barton, Sawyer, & Swanson 2007). Good readers are critical thinkers and notice details other readers miss or do not consider. Using observational skills requires children to slow down, focus on details, and construct meaning—skills essential to the reading process as well as to scientific inquiry.

Magnifying objects increases engagement

When the first-graders return to their room to continue their science lesson, they excitedly look through their collections. The observation period begins with a general class observation. The children then each draw the object they are observing. The drawing paper they use has a section in which to write what the drawing reminds them of and to state their ideas about the function of the object. On the day that Maria, Angelique, and Tasha collect clover and dandelions, several of their classmates also have dandelions, so the dandelion becomes the focus of the group observation.

Magnifying devices further intensify the first-graders' observations. Each group of desks has a collection of magnifying glasses, microscopes, and jeweler's loupes. Children first look through the microscopes, but they find the jeweler's loupes easier to manage and begin to use them. The jeweler's loupes—small, flared cylinders that look something like tiny top hats—enlarge the dandelions 10 times. Children hold the loupe so the wide end cups their eye. Using their free hand, they hold their dandelion about two inches from the lens and slowly bring it to the loupe.

When the first-graders observe the magnified dandelions, magic occurs. At first, the children sigh and laugh; then silence falls across the room as they concentrate on drawing the magnified dandelions.

A quiet murmur spreads as the first-graders complete their drawings. Then the children state their comparisons or analogies, which the teacher records on the front board. One child says, "The dandelion looks like the sun, round and yellow with rays around the edges"; another says, "It reminds

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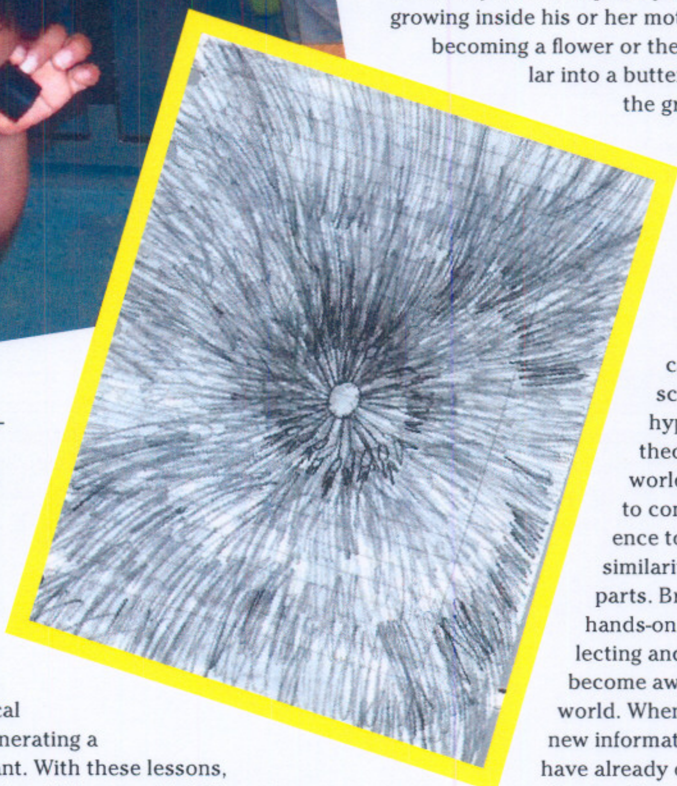
me of a flower garden, with flowers in flowers." Other analogies include "my grandma's flower garden," "circles—with circles in circles," " a dog's tail," "water troughs," "worms," and "hair."

The magnification devices are only part of the process. The questioning that the magnification process encourages in the children intensifies their focus.



Throughout the observation stage, the teacher asks the children, "What else does this look like? What else does it remind you of?" and "Why is it like that?" These questions become the foundation for making metaphorical or analogical connections and then generating a hypothesis about the plant. With these lessons, the teacher encourages the children to think like scientists, artists, and poets.

Why develop analogical thinking?

Analogies form a foundation for scientific inquiry. For instance, when studying the parts of the dandelion, the teacher might explain that sepals cover and protect the flower when it is still tender. As a child hears the explanation, he or she might say, "Oh, so the sepals protect the flower like a turtle's shell protects him? The sepals keep everything safe inside." When a child compares new information to prior knowledge, such as comparing sepals to the shell of a turtle, the new concept or term becomes concrete and the child more readily understands it. Making such connections promotes creative thought, expression, intellectual inventiveness, deeper comprehension, richer responses, and higher order cognitive functioning in all content areas (Cowan 2001; May, Hammer, & Roy 2006; Cowan & Albers 2007; Heid 2008).

The act of creating an analogy activates prior knowledge, produces new knowledge, and enhances the ability to communicate knowledge to others (May, Hammer, & Roy 2006; Heid 2008). According to neuroscience and cognitive theory, "early experiences become foundation metaphors for interpreting later experiences and language itself" (Sibbet 2008, 119). For example, a young child may compare a baby growing inside his or her mother to the process of a seed becoming a flower or the metamorphosis of a caterpillar into a butterfly. Firsthand experience lays the groundwork that allows learners to visualize information, to make connections from one body of information to another, and to build language and understanding from the connection.

Jacob Bronowski (1973; 1978) argues that metaphorical reasoning supports all of science. Our ability to create hypotheses—as well as to form theories to explain the natural world—depends on the ability to connect one part of our experience to another and to recognize similarities between the different parts. Bronowski explains that through hands-on experiences such as collecting and examining dandelions, we become aware of patterns in the natural world. When we reason, we understand new information in terms of patterns we have already observed.

During their study of natural items found on the playground, the children at Eastside become aware of patterns in nature and make connections from one discipline to another. During the discussion about the dandelion being a circle, one child adds ideas from a math lesson, stating that if you could fold the dandelion, it would be symmetrical. Another talks about the "wings" or "parachutes" on his mature plant. With each inquiry lesson, children become extremely quiet and focused when they observe and draw. Yet when they share their similes, metaphors, analogies, and hypotheses, they wave their

hands and eagerly share their ideas. Over the course of a semester, they become adept at the sort of patterning that characterizes analogical and metaphorical thinking. As an extension of this thinking, the children produce drawings and poems, and several began independent studies to learn more about the objects they had studied.

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Examining science through poetry

The teacher invites the children to share the similes and metaphors they have generated about the dandelion to form a composite or group poem. First one and then another first-grader adds ideas to create the following poem:

The Dandelion
Is yellow and round like a circle, like the sun.
It looks pretty like my grandma's flower garden
With flowers in flowers.
A dandelion has petals like a dog's tail
with petals
Like water troughs.

At this point, the teacher revisits the discussion about the function of body parts (such as fingernails and teeth), and then connects that discussion to the function of different parts of the dandelion. How might flowers in flowers, circles in circles, or petals shaped like water troughs help the plant to survive and flourish? Theo, who added the line "like water troughs," waves his hand and adds an ending to the poem, clarifying his idea for the function of the shape of the petals. Theo adds:

Like water troughs to hold the water
And keep it alive.

The experience of combining individual comparisons or analogies as a collective poem allows Theo to state a hypothesis that he then shares with his peers: specifically, the idea that the shape of the petal functions to allow the plant to capture water.

As the first-graders share their observations and drawings, the teacher engages them in a playful discussion about their observations. The teacher asks, "How does a dandelion petal look like a dog's tail? Could that be part of its function?" Through a gentle questioning process, the teacher guides the discussion in terms of correct scientific information.

After completing the group poem, children work through the same series of activities in teams to create additional poems and hypotheses. They select common plants, observe them with their jeweler's loupes, draw the plants, list similes, and then write poems. As they work, the teacher moves from table to table, questioning them: "What does it look like? What does it remind you of? So, if it reminds you of this, what would its function be?"

During this lesson and with each lesson that follows, children prepare a second, close-up drawing after looking through the jeweler's loupe or microscope. Then they write descriptions, which are often very detailed, and combine their individual descriptions into other stories and poems. Often their observations provide the skeleton for a poem, and so throughout the semester the magic of their observations is displayed in the halls of the school (in the form of drawings and poems or drawings with stories).

Describing observations through poetry can deepen children's understanding of abstract concepts. Using their own words, children create visual images and explain the phenomena of science, improving their retention of newly acquired information. By writing poetry, children develop the use of figurative language, a precursor to the abstract thinking needed for success in science. When creating poetry, careful observation is needed—a skill also required of scientists. Poetic writing requires comparing and contrasting, summarizing, describing, and interpreting—all important aspects of constructing scientific knowledge (LaBonty & Danielson 2005; Marcum-Dietrich, Byrne, & O'Hern 2009). In the lesson discussed above, creating metaphors from their drawings and then organizing the metaphors as a poem allows the children to "see" or understand the function of the shape of dandelion petals and to state the idea as a hypothesis.

Thinking like a scientist, artist, and poet

The jeweler's loupe and primary microscope are particularly important to this approach of developing metaphorical thinking. By blocking peripheral vision, these devices cut out distractions that may affect a young child's focus. They also increase the drama and wonder of the lesson, thus increasing children's engagement. The process of magnifying helps strip an object of its stereotypes so that real discovery occurs. It positions the first-grader to enter worlds that she or he never dreamed existed.

When children use the loupe, they can get lost in the maze of their own fingerprint or walk with their eyes across the taste buds of a friend's tongue. The children experience a world where "the mind and body work together to make sense of a material world that can never be absolutely fixed or elucidated, but where experience is the core of our knowing" (MacRae 2007, 160). Through the deep and intimate relationship the children form with the objects, they become familiar with them, using metaphorical and analogical thought to bridge prior knowledge and new concepts.

The wonder that is created leads to a great deal of questioning and requests for help with additional research. The most exciting research that occurs is the collecting and observing that children initiate.

Early in the semester at Eastside, children become enthusiastic about collecting, and by the end of the semester, they have gathered plants, insects, rocks, animal parts (preserved in alcohol), and soil samples. With their collections, they compare and contrast specimens, and then ask, "Why is it this way? Why is it like this?"

According to brain research studies, children achieve higher levels of understanding when they investigate, inquire, and lead discussions about information (Willis 2006). Classroom strategies that support child choice and hands-on/mind-on discovery activities, such as observation with magnifying devices, increase the flow of information to the learning centers of the brain, resulting in optimal learning. Beyond this benefit of the inquiry lessons, the opportunities for collaboration during the lessons allow children to perform as problem solvers rather than only as information receivers.

Conclusion

If early childhood educators hope to set children on a path to success in science, then they should actively encourage scientific inquiry in the early childhood curriculum. The sense of fun and joy that children experience when working with an inquiry-related curriculum most certainly influences their attitude about the subject. Beyond this positive effect on attitudes, approaching scientific

inquiry through an arts-integrated, pattern-searching approach allows children to make connections, think metaphorically, and build a deeper understanding of science content and processes.

With each inquiry lesson, the children worked through some of the first steps of scientific inquiry: they observed and they recorded. The first-graders worked with these skills until they became second nature, and today, they think like scientists. In addition to thinking like scientists, they now think in images. The format of their lessons—with an emphasis on observation, drawing, attending to details, and writing poetry—has positioned them to think metaphorically. Moreover, the format of their lessons has created in them a positive disposition about science and has allowed them to build a deeper understanding of science content and processes. These experiences have set them on a path to success in science.

The process of magnifying helps strip an object of its stereotypes so that real discovery occurs.

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